4158-6012-TU-000

TECHNICAL REPORT

GPO PRICE $
CFSTI PRICE(S) $
Hard copy (HC) 1.00
Microfiche (MF) .50
ff 653 July 65

"IMPACT IONIZATION FROM FRAGILE TARGETS"

July 1965

NASA CR 71015

Prepared for

National Aeronautics and Space Administration
Washington, D. C. 20546

Contract No. NASw-936

J. F. Friichtenicht
Prepared by
J. F. Friichtenicht
Manager, Meteoritics Dept.

D B Langmuir
Approved by
D. B. Langmuir
Director

FACILITY FORM 602

N66-20140 (ACCESSION NUMBER)	(THRU)
10 (PAGES)	1 (CODE)
CR 71015 (NASA CR OR TMX OR AD NUMBER)	24 (CATEGORY)

PHYSICAL ELECTRONICS LABORATORY
Physical Research Division

TRW Systems
One Space Park, Redondo Beach, California

IMPACT IONIZATION FROM FRAGILE TARGETS*

I. INTRODUCTION

The properties of hypervelocity impact on fragile or granular targets is of interest because of the similarity to meteoroid impact on the moon. There is considerable evidence to support the "dust layer" hypothesis for the lunar surface. The effects of meteoritic impact on the formation and moderation of such surfaces are not well understood. A number of experimenters, principally Gault, et al[1] from NASA Ames Research Center, have conducted cratering and penetration measurements on granular targets and have studied the properties and magnitudes of ejected material. This work was done using light gas gun techniques and was primarily concerned with simulation of meteoritic impact on the lunar surface.

It was first suggested by Maurice Dubin[2] of NASA Headquarters that the impact ionization effect and observations of high-speed impact in a low pressure gas environment might be valuable diagnostic tools for measurements of this type. The sections below describe the initial experiments done on the impact ionization effect using fragile targets.

II. EXPERIMENTAL PROCEDURES

Earlier work[3] indicates that the rapid energy release associated with the impact of high-speed particles on metallic surfaces results in vaporization and ionization of material near the impact point. For a number of particle-target material combinations, it was found that the total charge produced upon impact Q fits the empirical relationship

$$Q = k\,mv^3 \tag{1}$$

*This work supported by the NASA under Contract NASw-936.

where m and v are the particle mass and velocity, respectively, and k is a constant depending upon the materials involved. For a given particle material, Q depends upon the target material. All of the materials tested fall into two distinct groups. At a given velocity, more charge is produced with tungsten, tantalum, and platinum targets than with targets of indium, copper, berrylium-copper, and lead. Our interpretation of these results was that the primary role of the target was resistance to penetration which limits the energy release to a smaller volume.

The objective of the present experiment is to study the effect of target structure on the amount of ionization produced upon impact by a high velocity particle. The measurements were conducted in much the same manner as described in Ref. 3. The TRW Systems electrostatic hypervelocity accelerator[4] was used for all of the measurements. After passing through detectors for measurement of particle velocity and mass (see Ref. 4), the particles impacted on the target surface at normal incidence. A grounded grid is placed in front of the target. For this experiment, the target was biased 300 volts negative with respect to the grounded grid. The target to grid spacing was about 3 mm yielding an electric field at the target surface of 10^5 volts/meter. In this arrangement, free electrons created at the target surface are repelled while the positive ions are retained, thus producing a positive signal. The signal is amplified by a high input impedance amplifier and displayed on a dual beam oscilloscope along with the detector signal. The decay time constant of the input stage of the preamplifier is such that the amplitude of the output signal is proportional to total charge detected. The portion of the signal due to the particle charge was subtracted to yield the net charge created by the impact.

Two types of targets were used; one was a solid target of Armco iron while the other was a target made up of carbonyl iron spheres identical to those used in the accelerator. The targets are presumed to be similar except in structure, i.e., the iron spheres were very loosely bound. The particulate target was formed by milling a recess in a slightly magnetized holder. Particles were placed in the recess and smoothed as much as possible with a knife blade. The retaining power of the magnet was sufficient to hold the particles in place even when the target was in a vertical position. To ensure that target geometry was reproduced, a small disk of Armco iron was machined to fit the recess for use as the solid target.

III. EXPERIMENTAL RESULTS

The results of the experiment are illustrated graphically in Fig. 1 where the net charge produced Q is normalized to particle mass and plotted as a function of velocity for both types of targets. The points represent the data acquired with the solid target while the crosses represent the particulate target data. Within the scatter exhibited by the data points, there appears to be no marked difference in the impact ionization produced between the two types of targets at high velocities. Both sets of points follow the v^3 dependence which has been noted before. At lower velocities (~ 6 km/sec and smaller), less charge is produced by impact on the particulate target. In fact, about 10 data points, which are not shown on the graph, were below the limit of detectability. This is probably understandable, because at low velocities the strength of the target enters into most aspects of hypervelocity impact. Since the target composed of particles is so weak, most of the particle kinetic energy is probably absorbed by competing mechanisms.

The particulate target was examined with an optical microscope following particle bombardment. Although no quantitative measurements were made, it was evident that much larger craters were formed in the particle target than in the solid iron target. Further measurements on both the impact ionization effect and cratering in weak targets are required in order to fully assess the applicability of such experiments to simulated lunar bombardment. In particular, the possibility of obtaining weak targets with more precise properties should be explored. The effect of grain size should be evaluated, also.

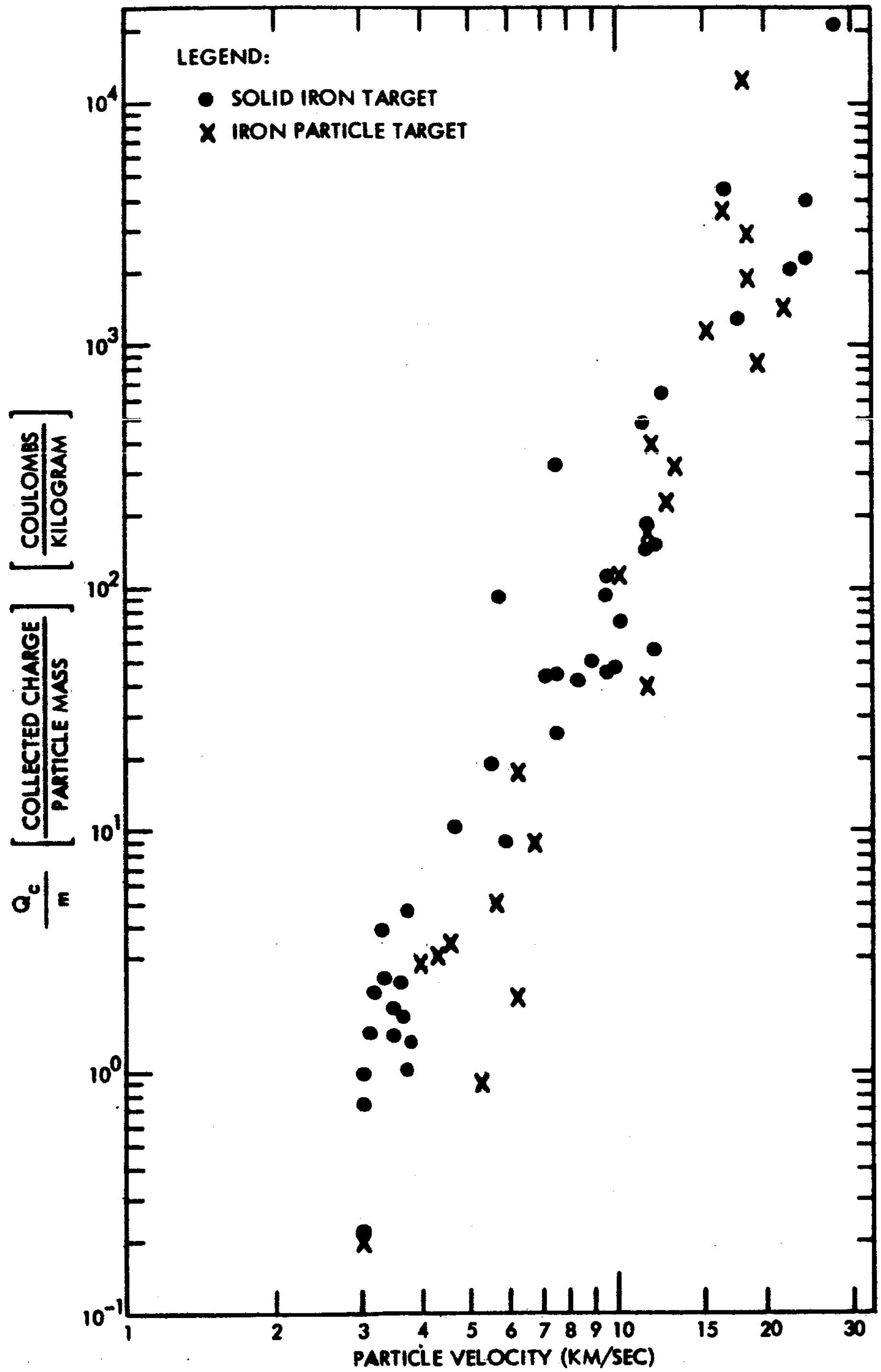

Fig. 1. Normalized Impact Charge Production as a Function of Particle Velocity for Solid and Particulate Iron Targets.

REFERENCES

1. Gault, Shoemaker, and Moore, "Spray Ejected from the Lunar Surface by Meteoroid Impact", NASA Technical Note D-1767, 1963.

2. Maurice Dubin, Private Communication.

3. J. F. Friichtenicht and J. C. Slattery, "Ionization Associated with Hypervelocity Impact", NASA Technical Note D-2091, August 1963.

4. J. F. Friichtenicht, "Two-Million-Volt Electrostatic Accelerator for Hypervelocity Research", Rev. of Sci. Instr., Vol. 33, 209-212, 1962.